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EXPERIMENTS ILLUSTRATING THE PRODUCTION AND NATURE OF LIGHT, PHOTOMETRY, THE FUNDAMENTAL PRINCIPLES OF ILLUMINATING ENGINEERING, AND THE ADVANTAGES OF GOOD LIGHTING

(Proceedings at the Joint Meeting of the Illuminating Engineering Society and the Science Masters Association, held at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W.7, on Tuesday, April 18th, 1944.)

It will be recalled that a preliminary account of this joint meeting has already appeared.* In what follows a summary of Dr. Wright's introductory address, with descriptions of the various experiments and the discussion thereon, is given.

This summary of the demonstrations, circulated previous to the meeting, is of interest:—

1. THE PRODUCTION OF LIGHT. (By Mr. L. T. Minchin and Mr. J. B. S. Smyth.)
   (a) By heating—examples of sources at different temperatures, including catalytic action employed in gas mantles.
   (b) By gas discharge.
   (c) By fluorescence.
2. THE NATURE OF LIGHT. (By Mr. J. S. Preston.)
   (a) Projection of spectrum—effect of recombining various strips of spectrum.
   (b) Effect of absorption in filter—distinction between additive and subtractive mixture.
   (c) Distinction between continuous and line spectra.
3. THE EYE. (By Dr. W. D. Wright.)
   (a) Model and demonstration to show similarity between eye and camera.
   (b) Model and experiment to show difference between eye and camera—eye movements, muscular control, variation in resolving power across retina.
4. PHOTOMETRIC PRINCIPLES. (By Professor J. T. MacGregor-Morris.)
   (a) Inverse square law for point sources; extension to large area sources and multiple sources as in an actual installation.
   (b) Relation between illumination and brightness of a surface, including cosine law and interplay of specular and diffuse components of reflected light.
5. THE BENEFITS OF GOOD LIGHTING. (By R. O. Ackerley.)
   (a) Demonstration to show you cannot tell whether you are seeing all there is to see.
   (b) Effect of increased illumination on ability to see small detail.
   (c) Effect of increased illumination on ability to see moving objects.
   (d) Importance of shadows in revealing shape.
   (e) Effect of increased illumination on apparent contrast.
   (f) Effect of glare.

The PRESIDENT (Dr. H. Buckley), in opening the proceedings, welcomed members of the Science Masters Association and expressed appreciation of the presence of Dr. Cullen, President of the Association, and other leading members. He hoped that the experiments would prove interesting to the large number of science masters present, and that some of them might find opportunities of repeating some of the demonstrations in connection with their own teaching. It was the intention to publish an illustrated description of them in the Society's Transactions.

The President then called upon Dr. W. D. Wright, who had kindly made arrangements for this meeting to be held at the Imperial College and had gone to considerable trouble in supervising the arrangements of the various experiments, to address the meeting.

Objects of the Meeting

Dr. W. D. WRIGHT said that in introducing these demonstrations his task was twofold. He had to explain (a) what they were going to do and (b) why they were going to do it. Taking the second of these questions

* Trans. Illum. Eng. Soc. (London), May, 1944, p. 93.

first, What was the purpose of these demonstrations?

The answer was, first and foremost, that they were intended to increase the interest of science masters in the problems of lighting. The Illuminating Engineering Society programme involved the discussion at its meetings of the various technical problems that were of interest to illuminating engineers. It was, however, also vitally concerned with the job of making the public as a whole aware of the importance of lighting to their health, happiness, and efficiency. In this respect the Society had a gospel to preach and was actively engaged in delivering its message with true missionary zeal.

In this connection Dr. Wright, still pursuing the same metaphor, recalled the lectures that were given at Bradford two or three months ago to over 1,000 children by one of the Society's biggest and best bishops, Mr. R. O. Ackerley, who was again among the prophets that evening. They did believe, as a Society, that good lighting could make a most important contribution to the national well-being; moreover, the present time, when reconstruction plans are constantly before us, was a most opportune moment for stating their belief in no uncertain terms.

There were many sections of the nation to whom the Society might, and no doubt would, present its case for better lighting, but he could imagine no better choice could be made than to the members of the Science Masters Association. There was no need for him to stress the advantage of inculcating ideas in the child if they were to become part of the permanent make-up of the adult, but since it was manifestly impossible for the Illuminating Engineering Society to have close contact with more than the fringe of the child population, the alternative was to make converts, if conversion were necessary, of the members of the teaching profession. Science masters were, of course, a peculiarly approachable body in this connection, since they could reasonably be expected to be interested, as scientists, in the scientific problems which arise and, as teachers, in the educational value of the experiments we shall be demonstrating. There should therefore be little need to apply any "softening up" process in order to create a receptive attitude to the ideas the Society is propagating.

Dr. Wright also expressed the hope that this meeting would be of some benefit to I.E.S. members, more especially in connection with future lecture demonstrations which members might be called upon to make in our campaign for good lighting.

Turning to the demonstrations, Dr. Wright said that the organisers of the meeting would have liked them to be a great deal more ambitious than they actually were. In fact, the programme represented merely the bare bones of a much more ambitious scheme which was originally put forward, but which had to be put on one side owing to war-time difficulties. It was at first suggested that an exhibition, or conversazione, in which many different experiments were to be demonstrated, might be held. This project must be deferred until after the war, and it could only be hoped that the smaller ration now being offered would make those present hungry for more.

In conclusion, Dr. Wright referred to the printed list of experiments, which were divided into five different sections. The first four dealt respectively with the production of light, the nature of light, the eye, and photometry. In each of these sections, one or two simple experiments will be demonstrated to bring out points of particular interest. It would be realised that many more experiments could have been included in each group. As far as possible, the equipment employed was relatively simple, so that comparable experiments should in many cases be possible in schools and elsewhere. In the final section, Mr. Ackerley would be dealing with the problems which were more essentially connected with illuminating engineering, and which would normally lie somewhat outside the usual school curriculum. They might for this reason have a special appeal to science masters, since it was common experience that boys and girls were very intrigued whenever they had the opportunity to

apply their science lessons to practical problems.

In these demonstrations an endeavour would be made to keep to a strict time-table, so that there would, he hoped, be an adequate opportunity at the end for comments and suggestions, questions and discussions.

1. The Production of Light.

The demonstrations illustrating the production of light were given by Mr. L. T. Minchin, who dealt with the phenomena of incandescence, as illustrated in the gas mantle, and by Mr. J. S. Smyth, who showed a variety of electric discharge lamps and lamps based on fluorescence.

Production of Light by Incandescence (Mr. L. T. Minchin).

The most straightforward way of producing light artificially is to heat a solid object to incandescence. The amount of light which is then radiated depends, of course, on the area of the object, its temperature, and on its emissivity. In order to show the effect of the latter factor it would at first sight seem desirable to show a number of bodies at the same temperature, but giving out differing amounts of light. Unfortunately, this is a very difficult thing to do because the temperature attained by a body is the result of an equilibrium between the heat received and the heat lost. The heat lost depends greatly on the emissivity and, in consequence, bodies having a low emissivity get very much hotter under conditions of the same heat input.

In this experiment three pieces of refractory material (they are actually "combustion boats," such as are used for determining the carbon content of steel) are placed in the flames of three meker-type bunsen burners at an angle of 45 deg. The first has been coated with uranium oxide by the application of a uranium salt before heating. This is practically a black body, and because of this the heat loss is a maximum, and it is the coolest of the three. It glows with a dull red light. The second is the untreated refractory which has an emissivity of about 0.4. You will see that it glows considerably brighter, and this is because the temperature is higher and a larger proportion of the radiant energy consequently comes within the luminous wave-length band. Its total radiant emission is bound to be less than the first one. The third specimen has been coated with a small amount of powdered gas mantle which is stuck to the boat by pressing it into a thin layer of moist kaolin. This mantle substance—99 per cent. thoria and 1 per cent. ceria—has an exceptionally low emissivity (about 0.05), although, thanks to the ceria present, this is as high as 0.8 in the blue region of the visible spectrum. In consequence, the specimen reaches a higher temperature and glows with a much whiter light.

Turning to the more practical aspect of light production, here are three gas mantles illustrating the same principle. The first has been dipped in a solution of an iron salt, and the deposit of iron oxide on the surface has greatly increased its overall emissivity, and so it glows with a very dull red light. In the second the percentage of ceria has been increased by dipping an ordinary mantle in a solution of cerium nitrate. You will see that although it is brighter than the first it is very much duller than the third, which is an untreated mantle as normally used. Because of the careful balance of a low overall emissivity with a high emissivity in the visible spectrum wave band, the brilliant light is obtained. This is very much brighter than the same powder on our piece of refractory because of the big loss of heat by conduction in that case.

These experiments illustrate the fundamental principle of gas lighting but, of course, the electric filament lamp depends on temperature radiation just as much. In that case, however, the incandescent solid is a "grey body," and the emission characteristics play a less important part.

Production of Light by Luminescence (Mr. J. S. Smyth.)

In introducing his subject Mr. Smyth recalled that, historically, the gas discharge tube is an older source of light than the more familiar incandescent filament lamp and gas mantle. It was, however, only in the first decade of this century that the classical researches of Faraday and

Crookes and the isolation of the rare gases by Ramsay and others, were exploited by Moore and Claude, who produced the first practical discharge lamps. Of these, the neon advertising tube is a familiar example. These lamps operate at low pressure, require high voltages and are usually rather long.

It is only comparatively recently that lamps of a suitable size for general lighting purposes, operated from normal electric supplies, have been made available. There are now many such lamps in general use; those using mercury vapour have been developed for the widest range of applications, and provide a useful series for demonstration.

An increase in pressure results in a smaller lamp and a higher efficiency: high pressure mercury vapour lamps for general lighting purposes range in power from 80 watts. to 400 watts, and take the form of an inner hard glass or quartz tube containing the discharge, surrounded by an outer jacket to prevent excessive loss of heat. The arc, which is some 1½ in. long in the smallest and about 6 in. long in the largest size, is stabilised by a choking coil which limits the current to the designed value. Generally, the pressure of the electric supply is insufficient to start the main discharge, and some special device is necessary for starting. An auxiliary electrode adjacent to one of the main electrodes will produce by glow discharge sufficient ionisation to allow the main arc to strike, and this is the method usually employed in high pressure lamps. At first, the discharge is at low pressure, but with increase in temperature more mercury is vaporised, and as the pressure rises to one or more atmospheres, the discharge constricts to a narrow column of light at the centre of the tube. The progression of events during the running-up period may conveniently be studied by projecting an image of the lamp upon a screen.

Examination of a colour chart in the light from a high pressure mercury vapour lamp during running-up will show that as the pressure rises, there is a slight increase in the amount of red light emitted. This is best shown with an 80-watt or 125-watt lamp, which operates at a higher pressure than the larger sizes. Even so, however, the colour rendering of the uncorrected lamp is unsatisfactory for many purposes, and the phenomenon of fluorescence has been exploited to modify the colour and increase the luminous efficiency of the mercury vapour lamp.

Most organic and inorganic substances fluoresce to some extent, as may be easily shown if a convenient source of ultra-violet radiation is available. For this purpose a "black lamp," which is an 80-watt or 125-watt high pressure mercury vapour lamp enclosed in a nickel glass jacket, is very useful. This lamp emits little visible light, but radiates strongly U.V. of the 3650A band; the dangerous short U.V. is absorbed by the jacket. When exposed to the lamp, the face, the hands, many coloured materials and other common objects will fluoresce quite strongly. Certain vegetable dyes, such as fluorescene and eoscene, exhibit fluorescence only when the solution, a property demonstrated by dropping a few crystals into a large flask of water. The fluorescence of organic materials, however, is far surpassed in brightness by certain inorganic compounds, such as the tungstates, silicates, and the sulphides usually with the addition of a minute but carefully controlled quantity of a metallic impurity, such as copper or manganese. Cardboard sheets painted with a suspension of sulphide type powders are valuable in demonstrating many effects of fluorescence and phosphorescence (i.e., the maintenance of emission of light after the source of U.V. has been cut off).

The powders may be divided into two classes, those sensitive to long U.V. (3650A) which may be used for demonstration with a "black lamp," and those sensitive to short U.V. (2537A) which can only be used when no glass is interposed between discharge and powder. That is to say, they can be activated by a quartz jacketed lamp emitting the dangerous erythemal U.V. radiation, which is undesirable for demonstration purposes, or they can be used inside a glass tube in direct contact with the discharge. They are now employed in this way to modify the radiation

and increase the efficiency of the low pressure discharge lamp. With certain colours, such as green, startling increases in efficiency are obtainable, as may be shown in a tube coated over half its length with powder, the remaining portion being clear. With a suitable mixture of powders, a close approximation to daylight* may be obtained with high efficiency, as in the new 5-ft. fluorescent lamp now popular in many factories: if desired, by modifying the proportions of the powder mixture, a warmer colour can be obtained. Where no half-coated lamp is available it is possible to demonstrate the modification of the colour of a discharge (though in this instance with no increase in efficiency) by surrounding an ordinary tubular high pressure mercury vapour lamp with a glass jacket coated with a powder such as zinc cadmium sulphide sensitive to U.V. of the 3650A band. It will be found that the intensity of the fluorescence falls rapidly with increase in temperature as the powder is heated by the lamp.

The foregoing was illustrated by a series of demonstrations and experiments.

(1). Projection upon a screen, by means of a normal 6″ focus projection lens, of the images of three types of H.P.M.V. lamp, during the running-up period and in the steady state.

(2). Fluorescence of organic and inorganic substances, excited by a 125 W. H.P.M.V. "black lamp." The effect upon the eyes, teeth, and skin, the appearance of fluorescence in solution, and the range of colours obtainable with inorganic powders were shown.

(3). Application of fluorescent powders to practical light sources. Lamps coated over only half their length with fluorescent powder, were used to indicate the increase in light output and improvement in colour possible by the application of the phenomenon of fluorescence.

The Nature of Light

Mr. J. S. Preston (Light Division, National Physical Laboratory)

*True daylight is very variable: the light from present lamps approximates to noonday sunlight.

arranged three simple lecture demonstrations.

Demonstration 1.—This demonstration shows the nature or spectral composition of the light emitted by a high-pressure mercury arc (commercial 80-W mercury lamp). Figure 1 is a plan-diagram of the apparatus used.

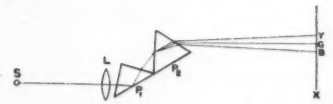


Fig. 1.

S is the light source, and L is a simple double convex lens suitable for throwing an image of S upon the white screen X. The focal length of L may conveniently be 8 or 10 inches. P_1 is a right-angled reflecting prism, and P_2 is a 60° flint glass dispersing prism (or a hollow prism filled with carbon disulphide). P_1 is used for convenience. By passage through it the light suffers a deviation equal and opposite to that produced by P_1, and the spectrum produced by the system is thus projected directly forwards. P_1 has its hypotenuse face in the same plane as the base of P_2, and P_2 is used in the position for minimum deviation. The inner tube of the lamp at S is parallel to the refracting edge of P_2, and the arc itself takes the place of the slit of the orthodox spectroscope. Images of the arc are thus produced on the screen X, instead of the usual spectrum lines—one image for each spectral component of the light from S.

In the diagram Y, G, B represent images corresponding to the yellow, green, and blue lines of the mercury spectrum. (The yellow line is double, but the simple system described will not easily show this.) A fourth image due to the violet (4047A) radiation is barely bright enough for purposes of demonstration. The hot electrodes of the lamp give unbroken spectrum bands on the screen, showing the continuous nature of the spectrum of an incandescent body. If a piece of didymium glass be placed in the path of the light, the yellow image disappears almost completely, while the

brightness of the others is not much reduced. The selective absorbing properties of this glass are thus shown. At the same time, with the yellow image removed, an adjacent diffuse red band is more easily seen, whose presence shows that an appreciable amount of red light is emitted by the mercury arc at high pressures (i.e., several atmospheres).

DEMONSTRATION 2.—This demonstration shows the spectrum of the white light from an incandescent filament, the recombination of the light in the spectrum to form white light again, the effect of absorption by coloured filters, and the separation of complementary colours and their mixture to form white.

The apparatus used is shown in Figure 2, in plan.

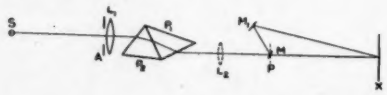


Fig. 2.

(a) S is the single-coil filament of a lamp such as an automobile bulb. The narrow filament coil takes the place of a spectroscope slit, its axis being perpendicular to the plane of the diagram. L_1 is a positive lens, preferably an achromatic doublet of focal length about 6 inches. P_1 is a 90° crown glass prism, and P_2 a 60° heavy flint prism. These two cemented together with balsam or joined with a film of cedar oil form a handy "direct-vision" prism giving sufficient dispersion for the present purpose. S, L_1, and the double prism are used in the same way as in Demonstration 1 to project a spectrum on the white screen X. Various colour filters can be placed in the beam of light near P_1 to show on the screen the effect of their absorption in different regions of the spectrum. To obtain the best focus of the spectrum it is useful to use a filter (such as didymium glass) which absorbs a very narrow band, and to make the adjustment, which shows this dark band most clearly on the screen.

(b) A mask A with a square aperture of, say, 1 in. side is placed over the lens L_1. A simple convex lens L_2 is then inserted. This may conveniently have a focal length of about 12 to 14 in., and its position is such that the mask A and screen X are in conjugate planes. An image of the aperture in A is then focused sharply on the screen. It will be noticed that the image is not square. This is because the prism combination P_1 P_2 is not being used at "minimum deviation" and so gives a magnification (actually a diminution when used as shown in the diagram) in its principal plane. It is now found that a miniature spectrum is formed in a plane P not far from L_2. The light forming this spectrum travels on, however, and recombines to form the white-light image of A upon the screen.

(c) If now a narrow upright obstacle, for instance a strip of white card 1 or 2 mm. wide, be placed in the plane P so as to obstruct the light in a narrow band of the spectrum, the image on X will appear of the colour complementary to that of the spectrum band removed.

(d) If, instead of a strip of card, a strip of thin plane mirror (such as galvanometer mirror) be used as an obstacle at M, the light removed from the spectrum can be reflected well to one side, and back on to the screen, by means of a larger piece of mirror M_1, where it forms another image of A. The image formed via M, M_1 is of the colour of the light picked out by M. The image formed by the direct light is of the complementary colour formed by the recombination of the rest of the spectrum. By suitable tilting of M_1 the former image may be made to overlap a part of the latter. The overlap is then white, while the two adjacent non-overlapping portions show the two coloured lights which combine to form the white. If M, M_1 are fixed rigidly to a single mounting, so that they can be moved together transversely, M can be made to travel through the spectrum, giving a continuously changing pair of com-

plementaries on the screen, which always form white where they overlap.

The light travelling via M and M_1 suffers loss by the two reflexions, and it is well to compensate for this by reducing also the intensity of the direct light. This is easily done by placing between M and X, and close to M, two or three layers of clear glass, so that all the light except that reflected out by M and M_1 has to traverse them. The number of layers of glass is chosen to eliminate the slight coloration otherwise noticeable in the "white" overlap.

DEMONSTRATION 3.—This demonstration provides an example of a subtractive colour mixture. Solutions of a blue dye and a yellow dye in water are mixed, giving a brilliant green solution. A test with the apparatus of Demonstration 2 (a) shows that the blue solution transmits the whole of the spectrum except the red and orange, while the yellow transmits the whole except the blue. The colour of the mixture is thus due to the subtraction, from the white light spectrum, of all the regions not transmitted by *both* dyes, i.e., the red, orange, and blue, leaving only the green in the light transmitted by the mixture. In contrast, an *additive* mixture of yellow and blue would, of course, include these two regions of the spectrum only, and not the green.

Dyestuffs suitable for this experiment are disulphine blue and nitrosodimethyl-aniline.

The Eye

Dr. W. D. Wright, who was responsible for these demonstrations, recalled that, in teaching the main features about the eye, it is customary to use the camera as an analogy. This is quite appropriate for certain aspects of the problem, and by means of models of sections of the eye and the camera (models were shown) you can make a useful comparison of the two lens systems, of the iris of the eye with the diaphragm in the camera, the retina with the photographic plate, the two methods of focusing, and so on.

But while this comparison between eye and camera is helpful, it has its limitations. There is no analogy with the variation in the performance of the eye with level of illumination, no adaptation mechanism, no explanation of why the eye gets fatigued, and the experiment to be described demonstrates a vital difference between the eye and the camera in regard to the resolving power at various angles off the axis of the system. In the camera, the resolution of the plate is a function of the size of the silver particles in the emulsion and is uniform over the whole area of the plate. In the eye, the resolving power of the retina depends on the size of the receptors—rods and cones—but this resolving power is far from uniform over the retina. This is in small part due to variation in the size of the receptors, of which there are in all some 120-130 million, but is primarily due to the fact that in the very centre of the retina each receptor is connected to an individual nerve fibre, whereas in the periphery many receptors converge on to a single fibre, so that the receptive unit covers a much greater area of the retina.

To test the resolving power, a series of letter E's can be used as test object, having the dimensions shown in Fig. 1. The resolving power will be expressed as the inverse of the angular subtense of the limbs of the letter, the angular subtense being measured in minutes of arc. The ob-

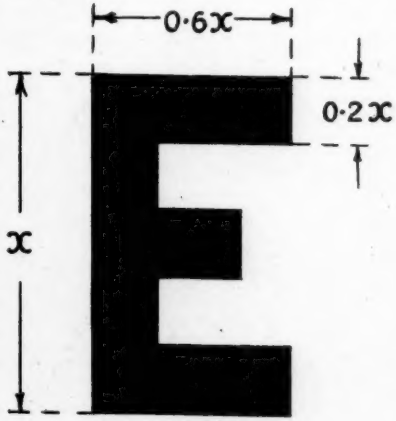


Fig. 1.

server, using his right eye, gazes steadily at the fixation point P, Fig. 2, while the test letter E is brought gradually nearer P along the

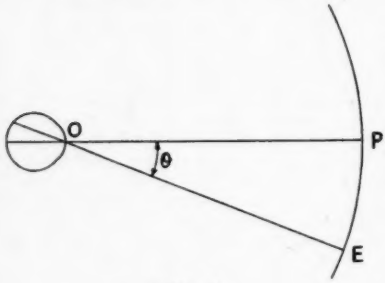


Fig. 2.

arc of a circle with centre O. The distance from O to P in the experiment was 19 ft. When the observer correctly distinguishes the direction of the arms of the E—upwards, downwards, to the right or to the left—the resolving power is recorded at the angle O to the axis at which the letter is recognised. This is repeated for various sizes of test object.

To determine the axial resolving power, a letter E is chosen of a size which can just not be distinguished when placed at P. The letter is then moved nearer to O along the line PO until the observer correctly identifies its orientation; from the distance at which the letter can be distinguished and the size of the letter, the angular subtense, and hence the resolving power can be calculated.

The results can then be shown graphically by plotting resolving power against O, and a curve of the type shown in Fig. 3 is obtained. This curve illustrates the very rapid decrease in acuity with distance from the fovea. It demonstrates that the eye is very much like a pointer which, to get a clear picture of the whole of a scene, has to scan one detail after another, somewhat in the manner of the scanning spot in a television system, although in no such orderly sequence. There is, however, nothing analogous to this in the camera.

At the same time, it must be noted that our sense of direction and our perception of space, particularly our stereoscopic sense, depend fundamentally on this "pointer" action of the eye. Hence, the loss of resolving power is in no sense a weakness of the eye, but rather a feature essential to its successful operation.

As illuminating engineers, this characteristic is important, because it means that, when we look at any object, we have to direct our two eyes on to the same point of the object. This requires remarkable co-ordination between mind and muscle—the eye muscles controlling the rotation of the eye—and when the observing conditions are bad, e.g., owing to bad lighting, the muscles are given a much harder task to secure the required co-ordination. This is undoubtedly one of the factors leading to eyestrain and fatigue.

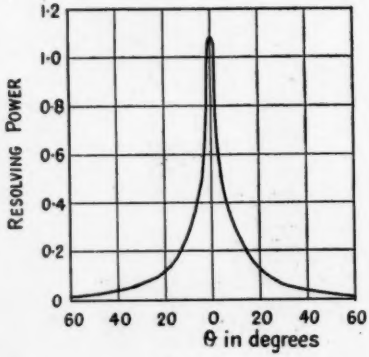


Fig. 3.

Photometric Principles

In view of the limited time available, Professor J. T. MacGregor-Morris devoted attention solely to photometric principles, which he illustrated by showing the application of the inverse square law for point sources, and its extension to sources of large area or multiple sources, as in actual installations.

Starting from the fact that (for so-called large scale effects) light travels in straight lines, the following are necessary consequences:—

The illumination produced at a distance of d feet

(i) from a Point Source varies as $1/d^2$,

(ii) from a Long Linear Source varies as 1/d,

(iii) from a Large Plane Source is independent of the distance.

(On consideration, the relation of these statements to similar theorems in heat and magnetism will be clear.)

In demonstrating these relations Professor MacGregor-Morris utilised a limited plane surface consisting of five 5-ft. fluorescent lamps mounted parallel to one another and 1 ft. apart on a large white board. (This "source" was kindly provided by Mr. R. O. Ackerley and Mr. W. R. Stevens.) The illumination from this source was received on a photo-electric cell, the distance of which could be conveniently varied, and which was attached to a galvanometer, mounted in a lantern, so that the image of the scale and pointer was projected on to a screen. The range of the shunt of the galvanometer was altered in the three cases, so that a deflection of reasonable magnitude, easily visible to an audience, could be obtained.

The results are shown in the accompanying table. They show that at some 6 in. from the source the illumination is practically independent of the distance, whilst at 3 ft. it varies inversely as the distance, and at or beyond about 8 ft. the inverse square law holds.

Position of Photo-electric cell.	Distance from Source.	Illumination (in arbitrary units).
Close to Luminous Area..... ...	0.35 ft.	4.5
	0.7 ft.	4.4
Farther away ...	1.5 ft.	4.4
	3.0 ft.	2.1
Still farther away ..	6.0 ft.	8.6
	12.0 ft.	2.2

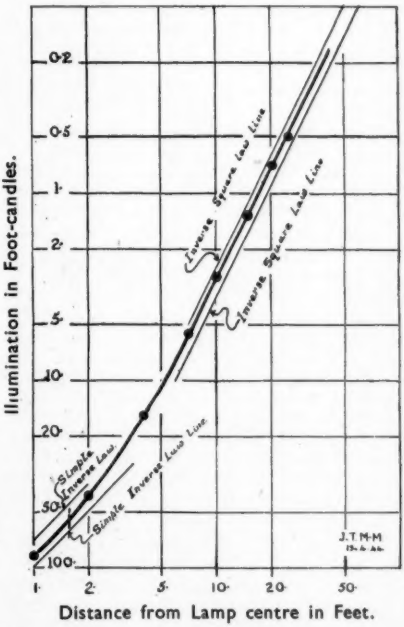
In order to show the practical application to the case of a single 5-ft. fluorescent lamp test-results furnished by Mr. W. R. Stevens, of the G.E.C. Research Labratories, are set out on log—log paper in Fig. 1. On such a graph the simple inverse law holds where the curve slopes at an angle of 45°—i.e., between 1 ft. and 2 ft.; and where the slope is double at 12 ft. and beyond, the inverse square law applies.

The Benefits of Good Lighting

The concluding series of demonstrations, by Mr. R. O. Ackerley, included some that had figured in his Presidential Address ("Seeing is Believing").

The first experiment was of the simplest character and was intended to show that one cannot be sure of seeing all that there is to see until one has tried out different levels of illumination. Simple patterns of dots and lines were drawn in faint chalk on a blackboard, the illumination on which was progressively increased. It was only at the highest level that the full pattern became clear. Similarly, when a photograph of a landscape was thrown upon the screen and the brightness was gradually raised, it could be seen that the amount of detail visible became pro-

Tests on a 5-ft. Fluorescent Lamp.
(Observations supplied by W. R. Stevens.)



gressively greater. This increase in clarity was due not only to the fact that small detail, unrecognisable at low illuminations, became evident in a good light; it was also the fact that at higher illuminations degrees of contrast, imperceptible in dim light, could be appreciated.

Another simple experiment showed the influence of brightness on speed of vision. When a disc is rotated at constant speed a sudden increase in illumination apparently causes the motion to "slow down." If the illumination is diminished, on the other hand, the disc appears to move faster, and, with a very dim light, one may even be unable to see whether it is moving or no. This phenomenon is due to the fact that at higher levels of illumination speed of vision is increased.

The previous experiments had all been contrived to show the benefits of more light, but Mr. Ackerley also showed that "more light," if present in the form of glare, might interfere with visibility. This was demonstrated by means of a large optical test chart, with lines of type progressively diminishing in size. When a very bright light was exhibited, in close proximity to the diagram, the perceptive power of the eye was diminished. The smaller types became indecipherable — though the large letters could still be read. It was also shown that the effect of this glare was much less apparent when the illumination was relatively high.

Other experiments were designed to illustrate the importance of shadow and the effect of the direction from which light comes. It was shown, for example, what a marked effect somewhat glancing light has on the appearance of silks and carpets, and how the appearance of a plaster cast of a face might become grotesquely distorted if light came from one direction only, and how, on the other hand, its features became blurred when the light came from all directions and there was no definite shadow.

A final exhibit was a small model of a living room, so arranged that the colour of the walls and ceiling could be varied. By means of the projection arrangement previously utilised in the demonstration by Professor MacGregor-Morris, a reading of the illumination in this small interior, which could be illuminated either by direct or indirect light, could be thrown upon the screen. Even with direct light the effect of substituting dark surroundings for light ones was evident from the decreased illumination. But with indirect lighting the effect was naturally much more pronounced, as in this case the available illumination was all obtained by reflection, and its value could easily be halved or doubled according to the nature of the surroundings.

DISCUSSION.

Dr. J. W. T. WALSH said that the occasion of the joint meeting with the Science Masters Association was a source of very great pleasure to the members of the Illuminating Engineering Society, for, while they all appreciated the extreme value and importance of getting across to the younger generation such ideas as had been demonstrated, they were quite powerless without the active aid of those responsible for introducing new ideas to the pupils in our schools. He congratulated the demonstrators on the very able manner in which they had staged and carried out the various experiments.

Everyone looked forward very keenly to an extension of opportunities for introducing new and practical ideas to young people in the years immediately ahead, when there would be more time to interest them in the many wonders of nature which at present were crowded out of an all-too-short school life. Therefore, the demonstrations were particularly opportune; when young people remained at school until they attained the age of 16, and ultimately 18, years there would be more opportunities for bringing such fascinating subjects before them.

Whilst witnessing the demonstrations, he had wondered whether any member of the S.M.A. might be inspired by them to draw up a little book giving outlines of experiments of that nature for the benefit of his colleagues in the Association, for nearly all those demonstrations should be well within the capacity of any school laboratory and workshop. Should any member of the S.M.A. be inspired to prepare such a book, and should he wish to include a description of lighting matters, he would find at his disposal the help and experience of any

member or members of the Illuminating Engineering Society.

Mr. E. W. M. HEDDLE (S.M.A.) expressed gratitude to the Illuminating Engineering Society for having suggested the demonstrations and for organising the meeting.

Commenting on Mr. Ackerley's demonstrations of the benefits of good lighting, he said he was reminded of an electrical engineer whom he had met and who had arranged the lamps around his lounge in groups of three, there being about 48 lamps altogether. Each of the lamps in each group was of a different colour from the other two, and when he entertained at his house he arranged the lighting according to the types of minds of his guests. For ordinary people the lighting was of the usual orange colour, for philosophical people it was blue, and so on.

It would be interesting to hear more about the reactions of the eye in good lighting and in comparative darkness. That matter was particularly interesting at the moment, in view of the achievements of our night-fighter pilots. Some people were almost blind when out of doors at night. It was not generally realised that the eye was really two instruments in one, and that adaptation to surrounding conditions of illumination required some time—a very brief time when the eye was light-adapted, a considerable time when the eye was dark-adapted.

Mr. G. H. WILSON, a member of both the I.E.S. and the S.M.A., said that as a member of long standing in the I.E.S. he was naturally very enthusiastic about the demonstrations and the excellence of them. But as a science master, of very much shorter duration, he confessed that he could not find it possible to get more detail into the already overcrowded school syllabus. Much of that which had been demonstrated was more specialised than the ordinary school syllabus at the present time, and in his view the syllabus was more specialised than it should be. Some of it verged on technology, and he felt it unwise to make the ordinary school teaching more and more technological.

On the other hand, the demonstrators had given some very useful tips which would be of great help in the ordinary school teaching of many of the subjects which already came within the normal syllabus.

The offer made by Dr. Wright, with regard to the provision of models of the eye, was most helpful. Having worked in an industrial research laboratory for a good many years, and having a school laboratory at his disposal at the moment, Mr. Wilson appreciated the difference between the two. Realising the difficulty which the average science master experienced in producing demonstration apparatus such as had been used at the meeting, he emphasised that it would be of great assistance if some of the manufacturers or other organisations could supply sets of apparatus required for such demonstrations. So far as he was aware, the half-coated fluorescent tube such as had been used at the meeting was completely unobtainable unless one were connected with one of the big manufacturing organisations.

Finally, he said the subject of good lighting probably came within the hygiene class, with ventilation, heating, and probably dietetics. However, he preferred to leave it to others to decide where such subjects should come in the school syllabus.

Mr. E. G. SAVAGE (L.C.C. Education Department) commented that the demonstrations and the descriptions of them constituted exactly the kind of thing which was most useful for members of the S.M.A. He recalled an occasion, years ago, when the Board of Education was framing some pamphlets on the teaching of science in senior schools. Senior schoolboys left school at the age of 14 years at that time, but later they would leave at the age of 15 or 16 years. But they were not the kind of youngsters that were found at secondary schools; they should not be taught heat, but heating; not light, but lighting; and not mechanics, but mechanism. The difficulty was, however, that so little material was available to indicate how best to put that kind of thing across. The joint meeting of the I.E.S. and the S.M.A., however, gave one ideas about it. It was true that under war conditions the educational authorities could not get hold of tubes such as those which had been demonstrated at the meeting; but no doubt they would be available after the war, and one looked forward to the post-war period, when it might be possible to teach by demonstrations and experiments such as had been made at the meeting.

One of the reasons why syllabuses were overcrowded was that we had inherited a lot of rather unsuitable material which had gathered around the encrusted old examination syllabuses. All sorts of things were added, but nothing was ever cut out. But probably a good

deal of the existing syllabuses could be cut out if it were desired to include the sort of thing that had been demonstrated at the meeting. It was difficult to put over to immature people all the lessons which had been given at the meeting, and there was much of the apparatus which was outside the range of a school laboratory at the moment—as, for instance, photoelectric cells, galvanometers with reversible shunts, and so on. However, he looked forward to the time when there would be a disposal of such instruments for other than warlike purposes, and when they could be made available to the schools, which were living on a rather thin layer of fat accumulated before the war.

Mr. P. WOODLAND suggested that there was likely to be a good deal of cutting down of the syllabuses for the School Certificate and the Higher Certificate. He was not sure that already photometry might not be entirely absent from some School Certificate syllabuses, for instance. But the meeting had given one an appreciation of the importance of trying to teach something about lighting to all those who left secondary schools at the age of 16 years. We should teach them something about the sources of light, photometry, and the scattering of light; it was very rarely indeed that one found a question on the scattering of light in any School Certificate paper on physics. That was a great pity.

It might be well to consider whether some of the more expensive apparatus could be made available for groups of schools; it could be arranged that during the course of a year certain apparatus was circulated among the groups. Thereby they would share the expense of buying it; further, owing to the scarcity of such apparatus in wartime, some schools would not have the opportunity to use it unless there were some grouping scheme in operation.

On behalf of the Committee of the Science Masters Association, the Physical Society and various other organisation, Mr. Woodland expressed thanks to Dr. Buckley for having so kindly suggested revisions in the first draft prepared by the Sub-Committee on definitions and notation in photometry. Many members of the S.M.A. might have been wondering what the Sub-Committee had been doing. It was, he hoped, on the point of publishing, in the "School Science Review," if not elsewhere, certain recommendations concerning notations and definitions in current electricity. It was hoped also to produce something very soon on illumination.

He did not know whether the technical institutions had seen any demonstrations of the type which had been given at the meeting, but he felt that they might very well be interested. After all, such matters came within the ordinary National Certificate course on electrical engineering, and it might be worth while approaching them.

Finally, as a member of the S.M.A., Mr. Woodland said he had enjoyed the meeting so much that he hoped it might be possible for the Association to arrange similar meetings with the mechanical and "heavier" types of engineers!

Mr. C. E. GREENSLADE suggested that when demonstrating with the type of apparatus used at the meeting it might be better to arrange something in the nature of a conversazione, where a number of experiments could be shown and discussion invited. On the other hand, when dealing with small boys it was possible to do quite a lot in the way of photometry, and so on, with the aid of quite simple materials, with which they made their apparatus and competed with each other in demonstrating it. Such work made them very keen; it was quite interesting and useful.

A SPEAKER inquired whether he would be charged a high rate per unit for electricity if he used fluorescent lamps—if he used a very efficient instrument, would the charge for electricity be increased?

Mr. G. H. WILSON said he believed that electricity tariffs were arranged more in relation to the times at which the load was taken than to the purpose for which the energy was used; at least, that was so in theory. Thus, the cooking and heating loads were usually cheaper than the lighting load because they were day-time loads; but in the evenings everybody wanted to use the lighting at about the same time, and electricity for lighting was charged for at a higher rate because it was the sort of load that came or used to come at peak load. Therefore, he supposed that more efficient lighting would be charged at the normal lighting rate.

Another SPEAKER, discussing the fairly widespread use of fluorescent lamps in modern offices, said he had had to work in an office by reflected light from strip lamps, which he believed were Osram 80-watt lamps, colour A. He did not know the composition of

colours used in colour A, but he did know that a variety of white lights could be obtained by the combination of various colours. He asked how the eyes were affected when one had to do a lot of reading and writing with the aid of that type of lamp, as compared with the old type of lamp, which gave a more yellow light. Often it had been said that people preferred to read by the light of the old paraffin lamp rather than that of the gas lamp. Electric light was said to be an improvement on the ordinary incandescent gas lighting. It would be interesting to know how each of those various types of light affected the eyes.

Again, he asked what was the effect, in the long run, of eliminating shadows. Was it beneficial to the human eye? His own experience and that of others seemed to indicate that it was not.

Mr. J. B. S. SMYTH replied that light from a colour A 5 ft. fluorescent lamp was a nearer approach to daylight than was that of the ordinary tungsten lamp, and the experience of many people was that it gave one a more lively and wakeful feeling. As an indication of its popularity, he said people were complaining that they wanted such light but could not get the lamps.

As to the effect of the light upon the eye, he suggested that any difference from other sources supposed to exist would arise probably from the fittings rather than from the light sources. Often, when people complained of light sources, of fluorescent or otherwise, their complaints should really be directed to the fittings placed around those sources.

He did not think that any light source in a normal room could completely eliminate all shadows. There must be shadows from tables, chairs, and the like. The 5 ft. fluorescent lamps, however, did cut out inconvenient shadows, such as the shadow of one's head when working at a bench or table. However, the lamps had been available for only a couple of years or so, so that there could not have been extended observations of the effect of the lighting upon the eye. He knew of no evidence that the 5 ft. fluorescent lamp could cause eye-strain or discomfort, if a well-designed fitting were used.

Mr. Smyth, dealing with the references to the difficulty of getting hold of mercury vapour lamps for demonstration purposes, said that doubtless most borough engineers had many on their hands at the moment, and they might be helpful.

With regard to colour, he said the light of the uncorrected mercury vapour lamp was by no means pleasant, and one would not suggest its use in the home. In the streets the level of illumination was much lower, and colours had not so great an importance there. At the National Physical Laboratory comparison had been made of revealing power in the light from tungsten filament, sodium vapour (yellow) and mercury vapour (bluish) lamps, in order to see whether there was any difference for street lighting, but no significant difference had been found between the three.

A SPEAKER, commenting on the recommendation that experiments such as those which had been demonstrated at the meeting should be introduced for class-room purposes, and the suggestion that they would be difficult to arrange, said that the very valuable work of the Lighting Service Bureau might perhaps be made more widely known. He had not been associated with school teaching; but the College of Technology in Manchester arranged an annual visit to the local Lighting Service Bureau, which was highly appreciated. The demonstrations at the Bureau were very well handled by the staff, and he was very glad to have the opportunity to pay tribute to their work.

Referring to Mr. Ackerley's experiment, in which he had rotated a gramophone table at normal speed and had shown that a symmetrical pattern on the table appeared to be rotating more slowly in a bright light than in a poor light, due to improved visual acuity, he said that it always seemed to him to rotate at the same speed, whether the lighting was bright or poor.

Mr. P. J. WALDRAM drew attention to the statement, in the latest report of H.M. Chief Inspector of Factories, that maximum output in factories was achieved only in good daylight, and suggested that the nearer we approached to daylight in any form of artificial lighting, the better, in all probability, would be the result. That point, he said, might well be impressed upon the young people of this and every other country.

He also suggested that science masters might with advantage recall a saying by Zoroaster, some 2,000 years ago, that true knowledge consisted of knowing what we did not know as well as that which we did. His memory of illuminating engineering extended back to the time when a claim was made before an American Court by a town council that an electrical contractor who had con-

tracted to install a 400-c.p. lamp at the junction of four roads, had actually installed a 100-c.p. lamp. The defence had contended, successfully, that if a photometer were used on each of the four roads and measured 100 c.p., the lamp must be of 400 c.p. (laughter). Since that time, said Mr. Waldram, we had all learned much; but he suggested that we did not always pay sufficient attention to that which we did not know, and there were still matters of importance which illuminating engineers were just beginning to learn. They had worked out a technique of measurement of physical phenomena, to which the eye usually responded physiologically but not invariably. The eye had its own psychological prejudices, by which it had been affected for some millions of years—and it sometimes responded to those prejudices more than to foot-candles. "Foot and candle disease" was dangerous and very infectious. We wanted to avoid teaching the young idea that they knew everything, or even a great deal, when they had learned about foot-candles, the inverse square law, and a few other things.

As an example of the advantage of inculcating thoughtful observation of familiar everyday phenomena, often disregarded because they were familiar, but capable of teaching much about visual reactions which scientists were only beginning to study, he said that if an ordinary observer, or even a technical observer, were taken into an ordinary room with a good large window, not heavily obstructed, on an ordinary day, he or she would say that the light intensity was about even throughout the room. There might be perhaps 10 per cent. difference as between the front and back of the room, but, generally speaking, it seemed to be about the same. If, however, it were measured photometrically, by taking photographs or in an other way, one would find that there was a reduction of something like 99 per cent. from the front to the back of the room. But our eyes could not detect this huge difference. Why? Having studied daylight assiduously for some 30 or 40 years, he wished that he knew.

Mr. J. S. PRESTON, whilst agreeing that some of the experiments could not be carried out without a certain amount of complication, said that the principles of optics could be demonstrated quite well by means of apparatus which could be made up quite easily. Its production was not beyond the ingenuity of those who were engaged in the teaching of science.

Dr. WRIGHT said that in connection with the eye there were a dozen or more experiments which could be set up with quite simple apparatus, if it were thought to be worth while. He had chosen the visual acuity experiment as a welcome change from one on adaptation. He suggested that perhaps a little too much had been made of the complexity of some of the demonstrations. Some could be made with the aid of Bunsen burners, liquids, and quite simple optical systems; and the effect of glare could be shown quite easily with the aid of one or two lamps.

Some of the matters dealt with in the demonstrations could not conveniently come within a school syllabus, but they could be made part of the programme of a school scientific society. In a way, that was a very good place for them. If two or three meetings of the school scientific society during the year, or even only one, were devoted to lighting problems, some good would derive from it.

PROFESSOR MACGREGOR-MORRIS added that the demonstration which he had made could be done with 49 flash-lamps, and the experiment could be made over shorter distances. The cost would then be about £2.

Mr. ACKERLEY, in a comment on Mr. Waldram's remarks, agreed entirely that we had much more to learn about our psychological and physiological reactions. But it would be a pity, he said, to gain the impressions that foot-candles did not matter. It was possible to over-emphasise them, but if we had not enough of them it would not be good for us.

The PRESIDENT (Dr. H. Buckley) proposed a hearty vote of thanks to Dr. Wright for having arranged the meeting and supervised the demonstrations, to him and his collaborators for the great trouble and time they had devoted to the work, and to the Imperial College for its hospitality.

Mr. W. ASHHURST, who seconded on behalf of the Science Masters Association, said he was pleased it had been stated that much of the work demonstrated could be done quite simply in the ordinary secondary school laboratory. He would like the members of the Illuminating Engineering Society to know that science masters did try to do

a lot of work such as had been demonstrated at the meeting. They tried to impress upon their students the differences of subtractive and additive combinations of colours, they carried out much work on the spectrum and made experiments on absorption.

With regard to expense, he said that some of the lamps used were not very expensive before the war. Many years ago he had bought an extra high-pressure mercury vapour lamp and had used it for many experiments in the school. The cost was about 15s. for the lamp and 35s. for the choke to go with it.

After expressing gratitude to the Illuminating Engineering Society for having made all the arrangements for the meeting, Mr. Ashhurst said that the S.M.A. wished to be associated with the expression of thanks to all the gentlemen who had demonstrated the experiments, as well as to the Imperial College for its hospitality.

The vote of thanks was carried with acclamation, and the meeting closed.

Additions to List of Members

The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

SUSTAINING MEMBER:—

Messrs. Geo. Bray and Co., Ltd. ..... *Representative*: E. Cawood
Leicester Place, Blackman Lane, LEEDS 2.

CORPORATE MEMBERS:—

Ball, W. ....." Mayhew," Arle Drive, CHELTENHAM.
Body, A. H. .....42, Herga Court, Harrow-on-the-Hill, MIDDX.
Brewster, Mrs. M. G. ." Welwyn House," New Tredegar, MON.
Carr, D. L.....91a, Caversham Road, LONDON, N.W.5.
Chard, W. A. .....Gloucester Gas Light Company, Eastgate Street, GLOUCESTER.
Collier, G. E. .....Electricity Department, EDINBURGH.
Corson, F. H. .....144, Tuffley Avenue, GLOUCESTER.
Dingwall, R. .....36, Gypsy Lane, Nunthorpe Station, Middlesbrough, YORKSHIRE.
Edgell, J. F. ....." Euroa," Highnam, GLOS.
Endicott, C. M. .....4, West Town Drive, Brislington, BRISTOL 4.
Felton, F. D. .....Stresa, Spring Hill Lane, Penn, WOLVERHAMPTON.
Fisher, E. ....." Leithville," Barnwood Avenue, GLOUCESTER.
Freeman, E. W. .....328, Scraptoft Lane, LEICESTER.
Garton, H. P. .....2, Cedar Mount, Edgerton, HUDDERSFIELD.
Harper, C. A. ....." Little Acre," Cropwell Butler, NOTTINGHAM.
Holt, J. M. .....55, Caversham Avenue, Palmers Green, LONDON, N.13.
Jamieson, J. .....15, Calton Hill, EDINBURGH.
Kerr, E. S. .....7, Pincott Road, Bexleyheath, KENT.
Limpitlaw, R. .....47, Iona Street, EDINBURGH 6.
Maude, R. .....66, Crown Street, HALIFAX.
McCabe, A. M. .....11, Ashley Gardens, WEST HARTLEPOOL.
McGill, D. .....24, Lindislane Road, Shipley, YORKS.
Melvin, D. D. .....15, Calton Hill, EDINBURGH.
Mitchell, W. F. .....4, Melville Crescent, EDINBURGH.
Morgan, I. R. .....2, St. Aldate Street, GLOUCESTER.
Munro, A. B. .....15, Calton Hill, EDINBURGH.
Piggott, G. .....H.M.S. St. Angelo, c.o. G.P.O., LONDON, E.C.
Pratt, A. .....81, Boswall Drive, EDINBURGH 5.
Purvis, H. D. .....53, Comiston Drive, EDINBURGH 10.

ADDITIONS TO LIST OF MEMBERS

Robinson, B. C. .....18, Southfield Road, GLOUCESTER.
Ryder, Alex. H. .....108, Prestbury Road, Cheltenham, GLOS.
Sayce, H. V. ....."Chelston," Bouncers Lane, Prestbury, GLOS.
Semple, N. F. .....James Kilpatrick and Sons, Ltd., 42, Frederick Street, EDINBURGH 2.
Smith, W. A. .....47, Iona Street, EDINBURGH 6.
Steel, R. W. .....Municipal Offices, The Promenade, CHELTENHAM.
Tombs, A. J. .....The Laburnums, Churchdown, nr. GLOUCESTER.
Varey, H. .....56, Hawthorne Terrace, Crosland Moor, HUDDERSFIELD.
Walker, H. P. .....c/o Plastics Dept., Imperial Chemical Industries, Ltd., "Belmont," The Ridgeway, Mill Hill, LONDON, N.W.7.
Waller, J. D. ..... 20. Carr Bottom Grove, BRADFORD.
Waterworth, T. H....8, Lyall Street, Eaton Square, LONDON, S.W.1.
Wolf, E. C. .....15, Oakfield Road, Finsbury Park, LONDON, N.4.

ASSOCIATE

Goldthorpe, H. H. ...Sewage Works, Deighton, HUDDERSFIELD.

STUDENTS:—

Bowles, P. J. .....253, Chester Road, Castle Bromwich, Near BIRMINGHAM.
Hirons, Miss P. .....28, Dalbury Road, Hall Green, BIRMINGHAM 28.
Leeming, G. .....32, St. Augustine's Terrace, Hanson Lane, HALIFAX.

TRANSFERS TO CORPORATE MEMBERS:—

Burdes, L. .....Bristol Corp. Electricity Dept., Dorset House, Clifton, BRISTOL 8.
Reed, D. J. .....Research Laboratories, The General Electric Co., Ltd., East Lane, Wembley, MIDDX.

The Library

The following presentations to the I.E.S. Library are reported:—

SECTION No.	TITLE.	AUTHOR.
1/7B	A Symposium on Illumination	—
12/10A	Photometry	J. W. T. Walsh
23/18	Electrical Technology	H. Cotton
23/24	The Application of Radiant Heat to Metal Finishing	J. H. Nelson and H. Silman.

The first two books mentioned are duplicates of works in special demand, and were presented respectively by Dr. J. W. T. Walsh and the Illuminating Engineering Publishing Company, Ltd.

It will be recalled that the original list of books in the Library appeared in THE TRANSACTIONS for April, 1939; additions have since been recorded.

Members are reminded that the Library at 32, Victoria Street, may be inspected by appointment, and that copies of most books can be borrowed under specified conditions.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form:—"Trans. Illum. Eng. Soc. (London)."

THE DISTRIBUTION OF LIGHT FROM READING LAMPS

By T. C. ANGUS, D.Sc., A.M.I.E.E. *(Fellow)*, and W. R. LUXTON *(London School of Hygiene and Tropical Medicine)*

(Communicated)

Amongst the plans for reconstruction now under consideration are those for the future lighting arrangements of homes and offices. In both of these situations there are localities where a relatively high illumination will be needed; for reading, writing, needlework, and hobbies in the home, as well as for the performance of the usual clerical tasks in offices.

In large offices, as in schools, where the occupants are generally close together, there is little doubt that there will be perpetuated the present-day method of affording a uniformly high level of illumination, sufficient to the needs of every individual. In the home, on the other hand, a general level of illumination in every part of a living room, high enough to allow of reading or sewing, will not only be unnecessary but probably unwelcome, and even disagreeable, to many persons.

In the same way it may not be desirable to maintain in the smaller office rooms, as used by senior members of a staff, a high level of uniform illumination. That little attention has been given to the construction and the effectiveness of the reading lamps commonly employed to augment local lighting in such localities is instanced by the two examples quoted below—the consideration of which has resulted in the present study.

An Examination of Two Conventional Types of Reading Lamp.

In a library it was found that the lighting afforded by small 40-watt table lamps of a conventional design was unsatisfactory. One of these lamps stood on each of the small, separate reading tables provided, whilst the room as a whole was illuminated to a low intensity by two large ornamental semi-direct fittings which gave an agreeable restful light but with too low an illumination at table level to allow of reading. —Fig. 1 shows the reading lamp in question.

It was found that such lamps gave an illumination of 17 ft.c. at the top of a page of a book but only 2 ft.c., or even less, at the foot of the page. In a City office clerks were found to be adding columns of figures under an illumination worse even than that described above. The general illumination of these offices, which were situated in high, old, dark buildings, was very low, but above the far end of each ledger were two clear 20-watt bulbs in a silvered reflector some 12 in. long by 3½ in. wide. Some of the desks sloped from back to front so that the light finally reached the foot of the ledger at a wide angle of incidence. The intensity at the top of one ledger was found to be 5.8 ft.c.,

Fig. 3.

Fig. 1.

falling to 1.8 ft.c. at the foot of the page.

The Study Lamp

It was to meet the needs of localities such as these cited above that the study lamp, now generally familiar, was introduced not very long ago. This lamp is the subject-matter of a British Standard Specification.

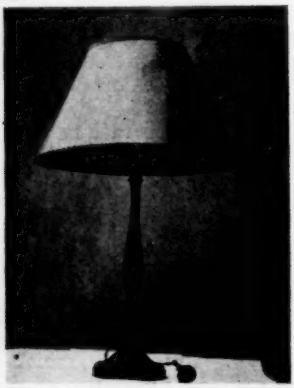


Fig. 2.

Fig. 2 shows such a study lamp. It incorporates a 100-watt pearl bulb in a fairly large translucent glass reflector diffuser, the whole surrounded by a wide, white-lined lampshade. The resulting illumination is so good that many persons on using these lamps for the first time express surprise and delight at the facility of seeing and the freedom from ocular fatigue afforded, in comparison with the sensations resulting from the local lighting often met with. This good effect results from the large area of the table illuminated to a high but reasonably uniform intensity, the absence of glare, the absence of dark areas in the background, and the considerable amount of light directed upwards on to the ceiling; which last not only reduces shadows but, adding to the general illumination of the room, in some instances renders additional general illumination unnecessary.

Solution of the Library Problem

It was proposed to substitute study lamps for the reading lamps originally supplied to the library when it was built, but this change would have entailed a 60 per cent. increase in the lighting load and was not permissible. This dilemma led to an investigation of the distribution of light from the existing reading lamps and to their modification so as to give an illumination more in keeping with the distribution and intensity given by the study lamp, although the improved lighting thus brought into being would be for the benefit of one person only to each lamp.

The height of the bulb was raised from 15 in. to 18 in. above the table by means of a short extension, and a 17-in. white-lined shade fitted instead of the narrower 10-in. shade. To utilise more of the light that would otherwise fall on the back of the shade, or escape upwards, a small reflector, an inexpensive commercial product, was held over the bulb at an angle of 45 deg. in a simple wire frame. This reflector consisted of eight small pieces of mirror held in a metal frame to form a frustum of an octagonal pyramid. A 40-watt pearl lamp was used, its diffusion being sufficient to prevent specular reflection of the filament in the mirrors. (Fig. 3 and Fig. 4 show these modifications.) The effectiveness of this conversion is recorded below, and as an upshot of this work all the reading lamps in the library were converted in like manner.

Comparisons of Effectiveness.

Iso-foot-candle diagrams for two types of 100-watt study lamp and for this library lamp, before and after

Fig. 4.

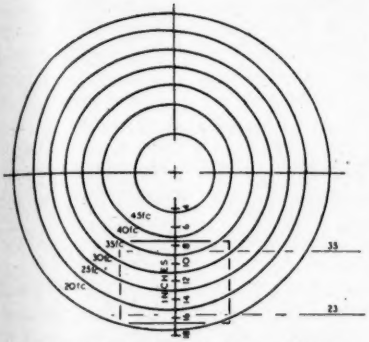


Fig. 5. First type of study lamp—100-watt, pearl diffusing glass, 17 in. shade.

modification, are given in Figs. 5, 6, 7, and 8. In each instance the rectangle in front of the axis of the lamp represents an open book 12 in. by 9 in. To estimate the ranges of illumination produced by the various lamps over such a field (the book in every instance having its further edge 7½ in. from the axis of the lamp), the foot-candles have been taken where the iso-foot-candle lines cross the top and bottom lines of print at the middle of each page; a line 1 in. from the top of the page and another 1 in. from the foot representing the top and bottom lines of print.

It will now be seen that for the first type of study lamp tested (Fig. 5), the intensity ranges from 35 to 23 ft.c.; for another study lamp with wider, less reflecting shade and a less translucent glass diffuser reflector 22 to 14 ft.c. (Fig. 6); for the original library lamp from 17 to 2 ft.c. (Fig. 7), and for the modified library lamp 28 to 15 ft.c. (Fig. 8). Thus, all but one of these lamps give a range of intensity within or well above the range advised for library tables by the I.E.S. Code (up to 10 to 15 ft.c.) By contrast will be noted not only the very wide range of illumination through which the eye has to work when reading a book illuminated by the conventional library lamp, but also that at the foot of the page

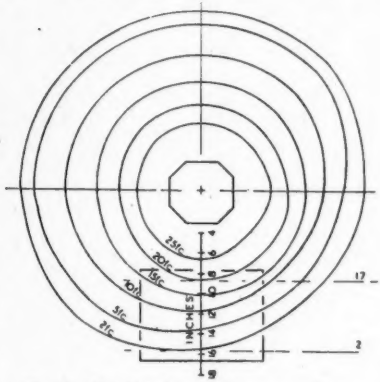


Fig. 7. Reading lamp—40-watt, no mirror, 10 in. shade.

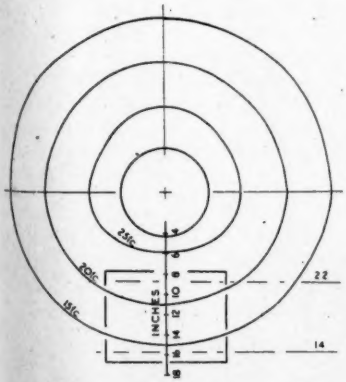


Fig. 6. Study lamp—100-watt, diffusing glass, 16 in. shade.

the illumination has dropped to 2 ft.c. an intensity recommended in the Code for halls and stairways but utterly unsuited to any kind of close work. It will be recalled that the values of illumination found on the clerks' ledgers were even lower.

Discussion.

Inspection of the above diagrams shows that the eye of anyone reading a book by the light from each of these four lamps is liable to experience considerable variations in brightness. In judging the effect of these variations, however, it is necessary to bear in mind that the sensation experienced, as a result of light entering the

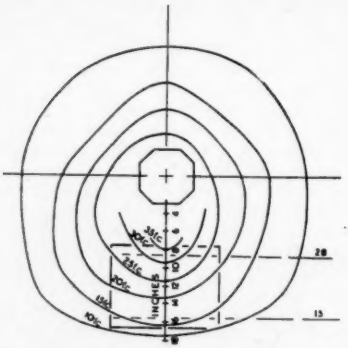


Fig. 8. Reading lamp—40-watt, mirror, and 17 in. shade.

eye, is proportional to the logarithm of the intensity of this light. It is therefore the *ratios* of the illuminations (and resulting brightnesses) encountered, and not their differences, that mainly affects the eye. Regarded on this basis (see Table) the two study lamps investigated give very much the best results, but the original library lamp, typical as this is believed to be of a large class, is clearly very much the worst of the four—not only is the actual value at the foot of the page (2 ft.c.) insufficient, but the ratio, nearly 1 to 9, quite excessive.

Source of Light.	Illumination on Page of Book (ft.c.)		Difference in Illumination (top and bottom of page).	Ratio of Illumination (top and bottom of page).
	Top.	Bottom.		
First Study Lamp... ...	35	23	12	1.5
Another Study Lamp... ...	22	14	8	1.6
Original Library Lamp... ...	17	2	15	8.5
Modified Library Lamp... ...	28	15	13	1.9

The Effect of Marked Variations in Illumination.

In what has been said above, the conditions liable to be met in reading the printed page of a book have been considered. But it is probable that quite wide variations in the illumination provided over the working area are often presented to other clerical workers. Such variations impose on the eye unconscious adjustments and unnatural efforts which must enhance fatigue, especially where the lower limit is well below the accepted comfort levels of illumination. Bearing in mind that the evolution of the human eye has taken place out of doors, and that the eye is an organ developed primarily for long distance vision in daylight; continuous work at close quarters (sewing, reading, and writing) may well be regarded as a physiological abuse of Nature's mechanism. Every practicable means to save unnecessary effort should therefore be taken. Readers should be given a reasonably constant illumination of not less than 10-15 ft.c., as recommended in the I.E.S. Code, over the printed page. If a field of greater uniform brightness can be attained, so much the better.

It should be stated that no special precautions, other than those taken by the average user were taken in setting up the study lamp. Possibly the results recorded, though good, could be improved upon.

It should also be made clear that the modified library lamp is not regarded as in any way an improvement on the study lamp which, besides providing diffused general lighting from the ceiling, gives a larger and more uniformly lighted background area than can be provided by the modified 40-watt lamp. The latter, however, may possess advantages in cases where there is reluctance to expend as much as 100 watts in a portable unit, and where a reasonable degree of general illumination exists. Such conditions may prove to be usual in homes of the future, and it is accordingly suggested that more attention may well be given to the design of lower powered reading lamps for individual use, coupled, possibly, with the introduction of supplementary British Standard Specifications for lamps of this type.

PROVISIONAL SYLLABUS OF MEETINGS

(SESSION 1944-1945)

SESSIONAL MEETINGS IN LONDON

Unless otherwise announced, meetings will be held at **5.0 p.m.**

1944.

Tuesday, Oct. 10th. Address by the President (Mr. E. Stroud). *(To be held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.)*

Tuesday, Nov. 14th. Sources of High Brightness, by Mr. J. N. Aldington. *(To be held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.)*

Tuesday, Dec. 12th. Motor-car Headlights, by Dr. J. H. Nelson. *(To be held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.)*

Dec. 27th, 28th and 29th. Christmas Lectures for Children. ("The Wonders of Lighting.")

1945.

Jan. 1st. Christmas Lectures for Children. ("The Wonders of Lighting.")

Tuesday, Jan. 9th. The Poetry of Light, by Mr. R. Gillespie Williams. *(To be held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2)*

Tuesday, Feb. 13th.
Tuesday, Mar. 13th.
Tuesday, April 10th.
Joint Discussion with the **R.I.B.A.; D.S.I.R. Report on the Lighting of Post War Buildings; Installation Problems** associated with **Fluorescent Lighting; The Response of the Eye to Light.**

Tuesday, May 15th. Annual General Meeting.

BATH AND BRISTOL CENTRE (WESTERN AREA)

(*Hon. Secretary:* D. J. Sawkins, 86, Redcliffe Street, Bristol.)

Meetings will commence at **7.0 p.m.,** *those in Bath being held in the Pump Rooms, and those in Bristol at the places stated.*

1944.

Sept. 8th. Optics, by Mr. J. Johnson. *(In Bath.)*

Oct. 6th. Address by the Chairman of the Centre (Mr. E. J. Ireland). *(Grand Hotel, Bristol, at* **6.30 p.m.***)*

Nov. 3rd. "Illuminated Display Advertising," by Mr. E. J. Pernet. *(In Bath.)*

Dec. 1st. Electricity for Aircraft, by Mr. F. E. Buckell. *(At Radiant House, Bristol.)*

1945.

Jan. 5th. Avoiding the Obsolete in Street Lighting, by Mr. F. Middleton. *(In Bath.)*

Feb. 2nd. Short Cuts in Illumination, by Mr. W. J. G. Davey. *(At Radiant House, Bristol.)*

Mar. 2nd. Address by the President (Mr. E. Stroud). *(In Bath.)*

April 6th. Stage Lighting, by Mr. R. G. Williams. *(In Bristol.)*

May 4th. Annual General Meeting, followed by an Address on **Special Industrial Lighting Problems,** by Mr. W. Imbie Smith. *(In Bath.)*

April 18th. Dance. *(To be held in the Pump Room, Bath.)*

BIRMINGHAM CENTRE (MIDLAND AREA)

(*Hon. Secretary:* C. J. Allderidge, 125, Moor Street, Birmingham.)

Meetings to be held at the Imperial Hotel, Temple Street, Birmingham, at **6.0 p.m.**
(Tea Buffet at **5.30 p.m.***)*

1944.

Oct. 6th. An Address by the Chairman of the Centre (Mr. J. G. Holmes).

Nov. 3rd. Debate. "That the Lighting of Class 'A' Roads by Stationary Lights is Necessary."
Proposers: Mr. F. L. Cator and Mr. F. F. Middleton.
Seconders: Dr. J. H. Nelson and Mr. C. F. Partridge.

Nov. 17th. Papers on **Recent Development,** by An Architect and An Illuminating Engineer. Joint Meeting with the Birmingham and Five Counties Architecural Association. *(To be held at the Society of Arts Gallery, New Street, Birmingham.)*

Dec. 1st. The Design and Lighting of a Post-War Civic Theatre, by Mr. L. G. Applebee. *(To be held at the Crescent Theatre, Birmingham.)*

PROVISIONAL SYLLABUS OF MEETINGS (SESSION 1944—1945)

1945.

Jan. 26th. A **"Brains Trust"** Meeting.

Feb. 23rd. Lighting and Illusion, by MR. P. HARTILL.

Mar. 23rd. Some Visual Problems for Illuminating Engineers, by DR. W. D. WRIGHT.

April 27th. Address by the President (MR. E. STROUD).

May 25th. Annual General Meeting. A Symposium on Lighting. Some Short Papers by Members.

CARDIFF CENTRE (SOUTH WALES AREA)

(*Hon. Secretary:* S. G. TURNER, Mervyn House, Frederick Street, Cardiff.)

Meetings will be held in the Cardiff Corporation Demonstration Theatre, The Hayes, Cardiff.

1944.

Oct. 13th. Mine Lighting, by DR. WELLWOOD FERGUSON. (*To be held at the South Wales Institute of Engineers, Cardiff, at* **3.30 p.m.**)

Nov. 2nd. Discussion on **Domestic Lighting.** (*Joint Meeting with the E.A.W.—Womens' Guild of Domestic Arts, at* **3.30 p.m.**)

Dec. 7th. Address by the President (MR. E. STROUD). (*To be held at the Mackworth Hotel, Swansea, at* **3.30 p.m.**)

1945.

Feb. 8th. The Poetry of Light, by R. GILLESPIE WILLIAMS. (*At* **3.30 p.m.**)

Mar. 8th. The Aesthetic Design of Lanterns, by DR. S. ENGLISH. (*At* **3.0 p.m.**)

GLASGOW CENTRE (SCOTTISH AREA)

(*Hon. Secretary,* M. W. HIME, E.L.M.A. Lighting Service Bureau of Scotland, 29, St. Vincent Place, Glasgow, C.1.)

Meetings will commence at **6.0 p.m.**

1944.

Oct. 20th. School Lighting, by MR. T. S. JONES. (*At "The Georgic" Union Street, Glasgow.*)

Nov. 10th. Address by the President (MR. E. STROUD). (*At "The Georgic," Union Street, Glasgow.*)

Dec. 13th. Infra-Red, by MR. F. E. ROWLANDS. (*At "The Cadoro," Glasgow.*)

1945.

Jan. 19th. Paper on The Gas Industry, by MR. F. C. SMITH. (*At "The Cadoro," Glasgow.*)

Feb. 16th.
Mar. 16th. } Subjects to be announced.

LEEDS CENTRE (NORTH MIDLAND AREA)

(*Hon. Secretary:* R. PYE, 46, Wellington Street, Leeds, 1.)

Meetings will be held in the Leeds Corporation Electricity Showrooms, The Headrow. Leeds, at **6.0 p.m.**

1944.

Oct. 2nd. Address by the Chairman of the Centre (DR. E. C. WALTON).

Nov. 6th. Lighting Pros and Cons, by MR. F. F. MIDDLETON.

Dec. 7th. The Poetry of Light, by MR. R. GILLESPIE WILLIAMS. (*Meeting place to be announced.*)

Dec. 27th and 28th. Christmas Lectures for Children. (In preparation.)

1945.

Jan. 8th. The Development of Mercury Discharge Light Sources, by MR. E. D. JONES.

Feb. 5th. Address by MR. F. C. SMITH.

Mar. 5th. School Lighting, by MR. T. S. JONES.

April 9th. Neon Signs, by MR. K. OLDHAM.

May 7th. Address by the President (MR. E. STROUD).

PROVISIONAL SYLLABUS OF MEETINGS (SESSION 1944—1945)

MANCHESTER CENTRE (NORTH WESTERN AREA)

(*Hon. Secretary:* ALAN H. OWEN, 11, Albert Square, Manchester.)

Meetings will be held in the Reynolds Hall, College of Technology, Sackville Street, Manchester at **2.30 p.m.**

1944.

Oct. 4th. Post-War Colour and Display Lighting, by MR. R. GILLESPIE WILLIAMS. *(To be held at the Royal Institution (Large Hall), Colquitt Street, Liverpool, at* **5.45 p.m.***)*

Oct. 5th. Stage and Colour Lighting, by MR. R. GILLESPIE WILLIAMS.

Nov. 11th. Street Lighting, by MR. J. M. WALDRAM.

Dec. 14th. Bright Light Sources, by MR. J. N. ALDINGTON.

1945.

Jan. 11th. Lighting for the Aircraft Industry, by MR. D. A. STRACHAN.

Feb. 8th. Industrial Decoration, by DR. J. H. NELSON.

Mar. 8th. Two Short Papers, by Members of the Manchester Centre.

NEWCASTLE CENTRE (NORTH EASTERN AREA)

(*Hon. Secretary:* STUART D. LAY, Ellison Buildings, Ellison Place, Newcastle-on-Tyne, 1.)

Meetings will be held in the Minor Hall, Oxford Street, Newcastle-on-Tyne, at **5.30 p.m.**

1944.

Oct. 4th. "Brains Trust" Meeting.

Nov. 1st. Visual Needs in Youth, by MR. R. W. GREGORY and MR. J. C. GILLIE. *(Joint Meeting with the British Optical Association.)*

Dec. 6th. The Trend of Discharge Lamp Development, by MR. M. W. HIME.

1945.

Jan. 3rd. Address by the President (MR. E. STROUD).

Feb. 7th. Principles of Good Lighting, by MR. H. V. FIELD.

Mar. 7th. Some Problems in Mine Lighting, by MR. C. S. CHUBB. *(Joint Meeting with the Association of Mining, Electrical, and Mechanical Engineers.)*

April 4th. Annual General Meeting.

NOTTINGHAM CENTRE (MIDLAND AREA)

(*Hon. Secretary:* C. S. CAUNT, 62, Thackeray's Lane, Woodthorpe, Nottingham.)

Meetings will be held in the Lecture Theatre of the City of Nottingham Gas Department, Parliament Street, Nottingham, at **5.30 p.m.**

1944.

Sept. 5th. Annual General Meeting, and Chairman's Address (MR. E. G. PHILLIPS).

Oct. 6th. Lighting: the Scientist's Point of View, by DR. J. W. T. WALSH.

Nov. 3rd. Lighting: the Ophthalmic Point of View, by MR. G. H. GILES.

Dec. 1st. Lighting: the Architect's Point of View, by MR. P. J. BARTLETT. MR. T. C. HOWITT, and MR. A. J. THRAVES.

1945.

Jan. 5th. Lighting: the Contractor's Point of View, by MR. J. ASHMORE.

Feb. 2nd. Lighting: the Street Lighting Engineer's Point of View, by MR. A. W. GOSTT,

Mar. 2nd. Lighting: the Industrial Lighting Engineer's Point of View, by MR. W. IMRIE-SMITH.

Apr. 6th. Lighting in Hazardous Situations, by MR. S. W. RICHARDS.

SHEFFIELD CENTRE (NORTH MIDLAND AREA)

(*Hon. Secretary:* J. A. WHITTAKER, Magnet House, Fitzalan Square, Sheffield, 1.)

Meetings will be held at the Nether Chapel, Norfolk Street, Sheffield, at **6 p.m.**

1944.

Oct. 16th. Glass, a Transmitter of Light, by DR. HOLLAND.

Nov. 7th. Modelling with Light, by MR. R. GILLESPIE WILLIAMS. *(To be held in the Lecture Theatre, Central Library, Sheffield.)*

Dec. 4th. Photometry, by MR. J. S. PRESTON.

PROVISIONAL SYLLABUS OF MEETINGS (SESSION 1944—1945)

1945.

Jan. 8th. To be announced.

Feb. 5th. Lighting in the Engineering Industry, by MR. F. L. CATOR.

March 5th. The Formulation of Recommendations for the Avoidance of Excessive Glare, by MR. J. B. CARNE.

April 9th. Infra-Red Design, by MR. LOWSON.

May 8th. Annual General Meeting. Address by the President (MR. E. STROUD).

BRADFORD GROUP (NORTH MIDLAND AREA)

(*Hon. Secretary:* A. J. HUTCHINSON, 27, Bolton Road, Bradford.)

Meetings will be held in Bradford Electricity Department Showrooms, Sunbridge Road, Bradford, at **6.45 p.m.**

1944.

Sept. 21st. The Civic Theatre: Its Planning and Lighting, by MR. L. G. APPLEBEE.

Oct. 12th. Applications of Fluorescent Lamps, by MR. W. R. STEVENS.

Nov. 10th. What the Eye Thinks About It, by DR. H. TOMLIN.

Dec. 8th. Lighting in the Engineering Industry, by MR. F. L. CATOR.

Dec. 28th and 29th. Christmas Lectures for Children: Colour Lighting, by MR. R. GILLESPIE WILLIAMS.

1945.

Jan. 11th. Infra-Red from Gas Heated Sources, by PROF. D. T. A. TOWNEND.

Feb. 8th. Bright Light Sources, by MR. J. N. ALDINGTON.

Mar. 8th. The Illuminating Engineering Problems of Vehicle Lighting, by DR. J. H. NELSON.

April 12th. The Lighting of Large Stores, by MR. O. C. WAYGOOD.

DERBY GROUP (MIDLAND AREA)

(*Hon. Secretary:* C. S. WHEELER, Grove Mansions, Burton Road, Derby.)

Meetings will be held in the Borough of Derby Electricity Showrooms, Irongate, Derby, at **6 p.m.**

1944.

Sept. 5th. Colour and Display Lighting, by MR. R. GILLESPIE WILLIAMS.

Oct. 3rd. Street Lighting, by MR. J. M. WALDRAM.

Nov. 7th. Domestic and Commercial Lighting in the Post-War Era, by MR. A. L. RANDALL.

Dec. 5th. Special Industrial Lighting Problems, by MR. T. S. JONES.

1945.

Feb. 6th Short Cuts in Illuminating Engineering, by MR. J. G. DAVEY.

Mar. 5th. Neon Lighting.

HUDDERSFIELD GROUP (NORTH MIDLAND AREA)

(*Hon. Secretary:* E. WOOD, 11, Long Grove Avenue, Dalton, Huddersfield.)

Meetings will be held in the Electricity Showrooms, Market Street, Huddersfield, at **7 p.m.**

1944.

Sept. 12th. Colour in Relation to Lighting, by DR. R. H. PETERS.

Oct. 3rd. Illumination and Illusion, by MR. P. HARTILL.

Nov. 7th. School Lighting, by MR. T. S. JONES.

Dec. 5th. The Poetry of Light, by MR. R. GILLESPIE WILLIAMS. *(To be held at the Technical College, Queen Street South, Huddersfield.)*

PROVISIONAL SYLLABUS OF MEETINGS (SESSION 1944—1945)

1945

Jan. 9th. **Infra-Red Radiation by Gas,** by PROF. TOWNEND.
Feb. 6th. **Illuminating Glassware,** by DR. S. ENGLISH.
Mar. 6th. **Neon Signs,** by MR. K. OLDHAM.
April 10th. **Development of Lighting Fittings,** by MR. S. C. MCDIARMID.
May 29th. **Lighting and Leisure,** by MR. E. P. MAWSON.
Sept. 4th. **Stage Lighting,** by MR. L. G. APPLEBEE.

LEICESTER GROUP (MIDLAND AREA)

(*Hon. Secretary:* F. J. SIANYON, 48, Eastfield Road, Leicester.)

Meetings will be held in the Leicester Corporation Electricity Department, Demonstration Theatre, Charles Street, Leicester, at **6 p.m.**

1944.

Oct. 3rd. **"Brains Trust"** Meeting.
Nov. 7th. **Human Optics,** by MRS. DOROTHY K. SOUPER.
Dec. 5th. **Illumination and Illusion,** by MR. P. HARTILL.

1945.

Mar. 6th. **Coloured and Directional Light as Applied to the Theatre,** by MR. L. G. APPLEBEE.
April 10. **What is Lighting Worth?** by MR. F. L. CATOR.
May 1st. **Infra-Red Drying: The Application of Town Gas to Paint Stoving and Other Drying Problems,** by MR. F. L. ATKIN.
June 5th. **Electric Lamp Manufacture,** by DR. A. B. WHITWORTH.

TEES-SIDE GROUP (NORTH EASTERN AREA)

(*Hon. Secretary:* R. H. BATEY, 14. Preen Drive, Acklam, Middlesbrough.)

Meetings will be held at the Cleveland Scientific and Technical Institute, at **6 p.m.**

1944.

Sept. 20th. **Aims of the Illuminating Engineering Society and Home Lighting,** by MR. W. E. DALBY.
Oct. 18th. **Industrial Lighting,** by MR. STEWART.
Nov. 15th. **Industrial Lighting in Relation to Safety and Vision,** by MR. E. W. MURRAY.

1945

Jan. 17th, **Street Lighting: Prospect and Retrospect,** by MR. J. M. A. MITCHELL.
Feb. 21st. **Principles of Good Lighting,** by MR. H. V. FIELD.
Mar. 21st. **Prevention of Dazzle by Polarised Light,** by MR. T. J. PICKERING.

GLOUCESTER GROUP (WESTERN AREA)

(*Hon. Secretary:* I. S. FREEMANTLE, 11, St. Aldate Street, Gloucester.)

(In process of formation.)

SESSION 1943—1944

LIST OF I.E.S. REGIONAL COMMITTEES

AREAS:

MIDLAND AREA.

Chairman: W. J. G. Davey. *Secretary:* C. J. Allderidge. *Committee:* C. S. Caunt, A. Hacking, J. Martin, F. H. Pooles, A. J. Pashler, W. J. P. Watson.

NORTH MIDLAND AREA.

Chairman: W. G. Thompson. *Secretary:* R. Pye. *Asst. Secretary:* J. A. Whittaker. *Committee:* J. T. Grimshaw, A. Kelso, J. W. Howell, J. H. Mollan, E. G. R. Taylor.

(In other Areas the only existing Centre Committee serves as the Area Committee.)

CENTRES:

BATH AND BRISTOL CENTRE (WESTERN AREA).

Chairman: J. B. Harris. *Vice-Chairman:* E. J. Ireland. *Joint Secretaries:* R. E. Tucker, and D. J. Sawkins. *Hon. Treasurer:* S. M. Richman. *Committee:* R. S. Hazell, W. A. Laughton, Miss E. L. Lee, Mrs. M. B. Probst, L. C. Rettig, W. Rush.

BIRMINGHAM CENTRE (MIDLAND AREA).

Chairman: A. J. Pashler. *Vice-Chairman:* J. G. Holmes. *Hon. Secretary:* C. J. Allderidge. *Hon. Treasurer:* F. F. Middleton. *Committee:* F. L. Cator, P. Hartill, J. G. Holmes, R. Hulse, H. A. Keeling, R. Mackenzie, C. F. Partridge, W. E. Prendergast, T. H. Varcoe.

CARDIFF CENTRE (SOUTH WALES AREA).

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